231 BENEFIT/COST RATIO ECONOMIC ANALYSIS

The purpose of the accident-based B/C ratio economic analysis is to provide an economic assessment of the extent to which a project or program may achieve its ultimate goal of reducing the number and/or severity of accidents. The B/C ratio analysis ultimately provides a means of selecting the most cost-effective countermeasure(s) for any given project.

The procedure involves the economic evaluation of improvement alternatives to develop effective improvement projects from the candidate alternatives. It is one of the most widely-used methods of screening programs and projects that are being considered for development.

The accident-based B/C ratio analysis should be made for those situations that are conducive to its use. The conclusion and recommendations for candidate projects should be based on the results of the B/C ratio analysis.

The accident-based B/C ratio method uses the ratio of expected benefits accrued (accident savings, reduced user costs, etc.) to the costs incurred for a countermeasure.

231.1 ANNUAL BENEFIT

The safety benefit is the anticipated reduction in the total annual number of accidents or accident frequency per countermeasure. The total annual accident cost saving (benefit) is obtained using FHWA's comprehensive motor vehicle accident costs (see page 231-6) and an appropriate accident reduction factor (ARF). The benefit should be evaluated for each countermeasure.

A comprehensive source for accident reduction factors is not available at this time. Available data and engineering judgment should be used to select appropriate accident reduction factors.

As a guideline to the magnitude of expected accident reduction factors for various types of improvements, reference may be made to the table on page 231-9, abstracted from *The 1996 Annual Report on Highway Safety Improvement Programs, Publication No. FHWA-SA-96-040*, and the listing on pages 231-10 through 231-20, *Accident Rate Reduction Levels Which May Be Attainable From Various Safety Improvements (Arizona Data) February 1991.*

231.2 ANNUAL COST

The cost of each alternative countermeasure is calculated as follows:

(1) Determine the total construction cost (initial design, right-of-way, construction, and other costs associated with the projects).

(2) Determine the service life of the countermeasure from the listing on page 231-7.

(3) Obtain or assume an interest rate, which is appropriate for current economic conditions, in percent.

(4) Compute the annual construction cost by multiplying the total construction cost by the appropriate capital recovery factor, based on the interest rate and service life of the countermeasure, from the table on page 231-8.

(5) Determine the annual estimated operating and maintenance cost for the countermeasure, and subtract the existing annual operating and maintenance cost to obtain the annual maintenance cost difference.

(6) Compute the total annual cost of the project (annual construction cost + annual maintenance cost difference).

231.3 BENEFIT/COST ANALYSIS

The B/C ratio is computed by dividing the annual benefit by the annual cost. The procedure is detailed on the worksheet on page 231-5.

When one alternative improvement involves several countermeasures, the following procedure should be used to calculate the overall accident reduction factor for that alternative improvement:

Accident reduction factor = $1 - (1 - ARF_1)(1 - ARF_2)(1 - ARF_3)$
$(1 - ARF_4)(1 - ARF_5)$ .....

where ARF_1, ARF_2, ARF_3, etc. are accident reduction factors for countermeasures 1, 2, 3, etc., respectively.

231.4 INCREMENTAL BENEFIT/COST ANALYSIS ($\Delta B/\Delta C$)

The incremental B/C ratio method may be used to determine whether extra increments of cost (e.g., widening the curve plus roadside improvements vs. curve widening only) are justified for a particular location or for considering improvements at two or more locations. This method assumes that the relative merit of a project is measured by its change in benefits and costs, compared to the next lower-cost alternative.

The steps for using the incremental B/C ratio method are as follows:

(1) Determine the benefits, costs, and the resulting B/C ratio for each countermeasure.

(2) List countermeasures with a B/C ratio greater than 1.0 in order of increasing cost.

(3) Calculate the incremental B/C ratio of the second lowest-cost countermeasure compared to the lowest-cost countermeasure. Pick the second lowest-cost countermeasure if this ratio is positive; else pick the lowest-cost countermeasure.

(4) Continue in order of increasing costs to calculate the incremental B/C ratio for each countermeasure compared to the last-picked countermeasure.

(5) Stop when the incremental B/C ratio (disregarding negative ratios) is less than 1.0.

To illustrate the use of this method, consider the costs and benefits in the following example. Notice that options must be ordered from lowest to highest cost. Each option may consist of a single countermeasure or a combination of countermeasures.

Illustration of Incremental B/C Analysis

Counter-measure	Annual Benefit	Annual Cost	B/C Ratio	Comparison of Counter-measures	Incremental Benefit	Incremental Cost	Incremental B/C Ratio (ΔB/ΔC)
B	$15,200	$1,510	10.1				
				B and C	$-2,400	$200	-12.0 (Pick B)
C	$12,800	$1,710	7.5				
				B and A	$25,600	$19,750	1.3 (Pick A)
A	$40,800	$21,260	1.9				
				A and D	$12,000	$3,240	3.7 (Pick D)
D	$52,800	$24,500	2.2				

From this example, countermeasure B (lowest-cost countermeasure) is first compared with countermeasure C, and countermeasure B is preferred to countermeasure C ($\Delta B/\Delta C = -12.0$). Countermeasure C is then excluded from further consideration. Countermeasure B is next compared with countermeasure A, and countermeasure A (the higher cost countermeasure) is preferred, since $\Delta B/\Delta C = 1.3$ (greater than 1.0). In this case, spending an additional $19,750 on countermeasure A will yield $25,600 of additional benefits. Countermeasure B is then eliminated from further consideration. Finally, countermeasures A and D are compared, and the additional $3,240 in cost from countermeasure D is compared with the $12,000 of additional benefits from countermeasure D. Thus, $\Delta B/\Delta C = 3.7$ between countermeasures D and A, and countermeasure D is the optimal solution based on incremental benefits and costs. Notice that countermeasure D was selected with a simple B/C ratio of 2.2, even though countermeasures B and C had B/C ratios of 10.1 and 7.5, respectively. This solution would be subject to funding availability, political considerations, environmental constraints, etc.

231.5 APPLICATION

The B/C ratio method requires that dollar values be placed on all estimated costs and the expected benefits related to the countermeasure. A countermeasure that has a B/C ratio

greater than 1.0 is considered economically justified. The countermeasure with the highest B/C ratio is normally the recommended alternative, unless the incremental B/C ratio method is used.

The B/C ratio method is recommended only when a set of costs for highway accidents (fatalities, injuries, property damages, etc.) has been established. ADOT has adopted FHWA's motor vehicle accident costs.

The method may be applicable to either an individual countermeasure or one consisting of several improvements. The B/C ratio should be evaluated for each alternative countermeasure. The selection of a countermeasure shall consider the highest B/C ratio, unless the incremental B/C ratio method is used.

231.6 STANDARD WORKSHEET AND TABLES

See the following pages.

ARIZONA DEPARTMENT OF TRANSPORTATION
TRAFFIC ENGINEERING GROUP
TRAFFIC DESIGN SECTION

BENEFIT/COST ANALYSIS WORKSHEET

Project Number	Date	Compiled by
Route	from Milepost	to Milepost
Alternative of	Type of Improvement	

BENEFITS

Accident Types	Annual Average	Accident Reduction Factor	Total Reduction	Unit Cost	Annual Benefit
Fatal				3,000,000.00	
Incap. Injury				210,000.00	
Non-incap. Inj				42,000.00	
Possible Inj.				22,000.00	
PDO				3000.00	
Unknown				3000.00	
			Total Annual Benefit		

COSTS

Total Construction Cost	
Project Life (Years)	
Interest Rate (%)	
Capital Recovery Factor (CRF)	
Annual Const. Cost = CRF x Total Const. Cost **(A)**	
Annual Maintenance Cost Difference (if applicable) **(B)**	
Total Annual Cost: **(A + B)**	

BENEFIT/COST

Annual Benefit	Annual Cost	Benefit/Cost Ratio

TRAFFIC ACCIDENT COSTS

(FHWA's comprehensive costs in 1994 dollars converted to 2002 dollars)

Accident Types	Cost
Fatal	$3,000,000
Incapacitating	$ 210,000
Evident	$ 42,000
Possible	$ 22,000
Property Damage Only	$ 3,000
Unknown	$ 3,000

SAFETY IMPROVEMENT PROJECT CODES, DESCRIPTIONS, AND SERVICE LIVES USED IN EFFECTIVENESS EVALUATIONS

Code	Description	Service Life (Years)
	INTERSECTION PROJECTS	
10	Channelization, left-turn bay	10
11	Traffic Signals	10
12	Combination of 10 and 11	10
13	Sight distance improvement	10
19	Other intersection improvements, except structures	10
1A	Combination of 10 and 19	10
1B	Combination of 11, 13, 19, and 65	10
	CROSS SECTION PROJECTS	
20	Pavement widening, no lanes added	20
21	Lanes added without new median	20
22	Highway divided, new median added	20
23	Shoulder widening or improvement	20
24	Combination of 20 - 23	20
25	Skid treatment - grooving	10
26	Skid treatment - overlay	10
27	Flattening, clearing side slopes	20
29	Other cross section or combinations of 20 - 27	20
2A	Combination of 20 and 26	15
	STRUCTURES	
30	Widening bridge or major structure	20
31	Replace bridge or major structure	30
32	New bridge or major structure (except 34 and 51)	30
33	Minor structure	20
34	Pedestrian over- or under-crossing	30
39	Other structure	20
	ALIGNMENT PROJECTS	
40	Horizontal alignment changes (except 52)	20
41	Vertical alignment changes	20
42	Combination of 40 and 41	20
49	Other alignments	20
	RAILROAD GRADE CROSSING PROJECTS	
50	Flashing lights replacing signs	10
51	Elimination by new or reconstructed grade separation	30
52	Elimination by relocation of highway or railroad	30
53	Illumination	10
54	Flashing lights replacing active devices	10
55	Automatic gates replacing signs	10
56	Automatic gates replacing active devices	10
57	Signing, marking	10
58	Crossing surface improvement	10
59	Other railroad grade crossing improvement	10
5A	Any combination of 50, 54, 55, 56, 57, and 58	10
	ROADSIDE APPURTENANCES	
60	Traffic Signs	6
61	Breakaway sign or luminaire supports	10
62	Road edge guardrail	10
63	Median barrier	15
64	Markings, delineators	2
65	Lighting	15
66	Improved drainage structures	20
67	Fencing	10
68	Impact attenuators	10
69	Other roadside improvements	10
6A	Combination of 60 - 64	10
6B	Combination of 64 and 68	10
6C	Combination of 60 and 62	8
6D	Combination of 60 and 64	4
6E	Combination of 62 and 69	10
6F	Combination of 62, 66, and 69	10
6G	Combination of 60 and 63	10
	OTHER SAFETY IMPROVEMENTS	
90	Safety provisions for roadside features and appurtenances	20
99	All projects not otherwise classifiable	20
9A	Combination of 11, 26, and 69	10
9B	Combination of 26 and 66	15
9C	Combination of 27, 30, 62, and 99	20
9D	Combination of 11 and 60	8
9E	Combination of 11 and 64	6
9F	Combination of 23, 26, and 62	15
9G	Combination of 27, 61, 62, and 64	10
9H	Combination of 22, 39, and 65	20
9I	Combination of 23, 61, 62, 64, 65, and 66	15

INTEREST FACTORS FOR ANNUAL COMPOUNDING INTEREST (EQUAL PAYMENT SERIES)

CAPITAL RECOVERY FACTOR

Year	8%	10%	12%	14%	16%
2	0.5608	0.5762	0.5917	0.6073	0.6230
4	0.3019	0.3155	0.3292	0.3432	0.3574
6	0.2163	0.2296	0.2432	0.2572	0.2714
8	0.1740	0.1874	0.2013	0.2156	0.2302
10	0.1490	0.1627	0.1770	0.1917	0.2069
15	0.1168	0.1315	0.1468	0.1628	0.1794
20	0.1019	0.1175	0.1339	0.1510	0.1687
25	0.0937	0.1102	0.1275	0.1455	0.1640
30	0.0888	0.1061	0.1241	0.1428	0.1619

EVALUATION OF SAFETY IMPROVEMENTS BY CONSTRUCTION CLASSIFICATION
1974 -1994

Construction Classification	Percent Reduction in Accident Rates After Improvements		
	Fatal	Nonfatal Injury	Combined Fatal+Nonfatal Injury
INTERSECTIONS AND TRAFFIC CONTROL			
Turning lanes & Traffic Channelization	48	26	26
Sight Distance Improvements	*56	*43	*43
Traffic Signs	32	15	15
Pavement Markings & Delineators	15	5	6
Illumination	38	14	14
Upgraded Traffic Signals	40	22	22
New Traffic Signals	*53	22	23
STRUCTURES			
Widen or Modify Bridge	49	30	31
New Bridge	86	69	70
Replace or Improve Minor Structure	36	20	21
Upgrade Bridge Rail	75	29	33
ROADWAY			
Construct Median for Traffic Separation	71	28	30
Widen or Improve Shoulder	21	12	12
Realign Roadway	63	41	42
Overlay for Skid Treatment	18	18	18
Groove Pavement for Skid Treatment	33	15	15
ROADSIDE			
Relocated/Breakaway Utility Poles	32	45	44
Upgrade Guardrail	36	8	9
Upgrade Median Barrier	*65	20	22
New Median Barrier	64	12	15
Impact Attenuators	*38	34	34
Flatten Side Slopes	*26	27	27
Remove Obstacles	60	23	25
RAILROAD-HIGHWAY CROSSINGS			
Upgrade Flashing Lights	85	35	44
New Flashing Lights	87	79	81
New Flashing Lights & Gates	92	85	86
New Gates	92	74	78

Note: * indicates no significant change at the 95 percent confidence level.

(Adapted from The 1996 Annual Report on Highway Safety Improvement Programs, Publication No. FHWA-SA-96-040)

ACCIDENT RATE REDUCTION LEVELS WHICH MAY BE ATTAINABLE FROM VARIOUS SAFETY IMPROVEMENTS (ARIZONA DATA)

ACCIDENT REDUCTION FACTOR CATEGORIES

1 - ROADWAY IMPROVEMENTS

- 1-1 Lane Addition
- 1-2 Lane Widening
- 1-3 Shoulder Widening
- 1-4 Two-Way Continuous Left – Turn Lane
- 1-5 Realignment
- 1-6 Shoulder Grooving
- 1-7 Skid – Resistant Overlay
- 1-8 Truck Escape Ramp
- 1-9 Brake Check Area

2 - ROADSIDE IMPROVEMENT

- 2-1 New Guardrail
- 2-2 Upgraded and / or Extended Guardrail
- 2-3 Drainage Structure Extensions
- 2-4 Slope Flattening
- 2-5 Vegetation / Obstacle Removal
- 2-6 New/Upgraded Median Barrier
- 2-7 Impact Attenuators
- 2-8 Object Markers
- 2-9 Delineation
- 2-10 Animal Fencing
- 2-11 Animal Reflectors
- 2-12 Snow Fencing
- 2-13 Rockfall Containment
- 2-14 Illumination

3 - INTERSECTIONS AND INTERCHANGES

- 3-1 New Signals
- 3-2 New Signals and Geometric Revamp
- 3-3 Revamped Signals
- 3-4 Revamped Signals and Geometric Revamp
- 3-5 Left–Turn Phasing
- 3-6 Turn Lanes
- 3-7 Geometric Ramp
- 3-8 Illumination
- 3-9 Sight Distance Improvement
- 3-10 Channelization Pavement Markings
- 3-11 Channelization Signing
- 3-12 Cross Road/Side Road Signing
- 3-13 Stop Signs
- 3-14 Yield Signs
- 3-15 Signal Removal

ACCIDENT RATE REDUCTION LEVELS WHICH MAY BE ATTAINABLE FROM VARIOUS SAFETY IMPROVEMENTS (ARIZONA DATA)

4 - TRAFFIC CONTROL DEVICES

4-1	Edgeline Markings
4-2	RPMs
4-3	Rumble Strips
4-4	New Curve Signing
4-5	Upgraded Curve Signing
4-6	Icy Pavement Signing
4-7	Slippery When Wet Signing
4-8	Narrow Bridge Signing
4-9	Watch For Rocks Signing
4-10	Animal Warning Signs
4-11	Interstate Signing

5 - PEDESTRIANS

5-1	Sidewalks
5-2	Pedestrian Overpass
5-3	Pedestrian Signing

6 - STRUCTURES

6-1	Bridge Widening
6-2	Bridge Replacement
6-3	New Bridge
6-4	Bridge Barrier Upgrade

7 - RAILROAD – HIGHWAY CROSSINGS

7-1	New Flashing Lights
7-2	Upgraded Flashing Lights
7-3	New Gates and Flashing Lights to Replace X- Bucks
7-4	New Gates to Supplement Flashing Lights
7-5	Surface Improvement
7-6	Signing
7-7	Pavement Markings

ACCIDENT RATE REDUCTION LEVELS WHICH MAY BE ATTAINABLE FROM VARIOUS SAFETY IMPROVEMENTS (ARIZONA DATA)

			% REDUCTION IN ACCIDENT RATES				
TYPE OF IMPROVEMENTS	**NO OF PROJECTS**	**NO OF BEFORE ACCT'S**	**ALL**	**FATAL**	**INJURY**	**FATAL & INJURY**	**PDO**
1 – ROADWAY IMPROVEMENTS							
1-1 LANE ADDITION	30						
All Accidents		2719	25	39	23	23	27
Rear-End		931	32	67	28	28	35
Run- Off – Road		542	44	55	44	45	44
SS / Same		248	30	100	36	37	28
SS Opp & Head- on		80	53	100	39	70	59
1- 2 LANE WIDENING	6						
All Accidents		491	56	58	57	57	54
Run- Off – Road		59	49	100	35	41	54
SS / Same		31	52	0	43	43	54
SS Opp & Head- on		10	70	0	100	100	25
1-3 SHOULDER WIDING	16						
All Accidents		600	57	48	59	58	57
Run- Off – Road		242	60	25	57	54	65
SS / Same		34	41	100	75	78	28
SS / Opp. & Head on		24	75	33	80	72	83
Pedestrian		14	71	86	57	71	0
1- 4 TWO- WAY LEFT-TURN LANE	19						
All Accidents		1254	30	40	20	20	35
Rear- End		407	36	0	38	38	34
Left- Turn		147	33	100	0	2	48
Run- Off- Road		134	37	100	(3)	0	49
Pedestrian		53	19	0	19	18	50
SS / Opp. & Head- On		25	36	0	50	50	27

NOTE: Underlined numbers represent statistically significant rate reductions. Numbers in parentheses represent rate increases

ACCIDENT RATE REDUCTION LEVELS WHICH MAY BE ATTAINABLE FROM VARIOUS SAFETY IMPROVEMENTS (ARIZONA DATA)

			% REDUCTION IN ACCIDENT RATES				
TYPE OF IMPROVEMENTS	**NO OF PROJECTS**	**NO OF BEFORE ACCT'S**	**ALL**	**FATAL**	**INJURY**	**FATAL & INJURY**	**PDO**
1- 5 REALIGMENT	26						
All Accidents		459	48	33	56	55	42
Run- Off- Road		190	66	33	71	69	62
Rear-End		71	37	0	42	42	34
SS / Opp. & Head- On		27	85	67	89	83	87
SS/ Same		26	54	0	57	57	53
1- 6 SHOULDER GROVING	18						
All Accidents		1210	18	15	18	18	17
Run - Off - Road		711	27	12	27	26	26
1-7 OVERLAY	177						
All Accidents		11278	9	2	4	4	13
Rear – End		3047	19	25	18	18	20
Run – Off- Road		2500	13	(16)	11	10	15
Wet Pavement		1191	39	61	25	27	43
1-8 TRUCK ESCAPE RAMP	3						
All Accidents		111	18	(75)	28	20	16
Def. Brakes		7	(14)	(100)	0	(100)	20
Rear – End		9	33	0	71	71	(100)
1-9 BRAKE CHECK AREA	2						
All Accidents		42	45	100	55	58	50
Def. Brakes		1	100	0	100	100	0
2– ROADSIDE IMPROVEMENTS							

NOTE: Underlined numbers represent statistically significant rate reductions. Numbers in parentheses represent rate increases

ACCIDENT RATE REDUCTION LEVELS WHICH MAY BE ATTAINABLE FROM VARIOUS SAFETY IMPROVEMENTS (ARIZONA DATA)

			% REDUCTION IN ACCIDENT RATES				
TYPE OF IMPROVEMENTS	**NO OF PROJECTS**	**NO OF BEFORE ACCT'S**	**ALL**	**FATAL**	**INJURY**	**FATAL & INJURY**	**PDO**
2-1 NEW GUARDRAIL	43						
All Accidents		409	19	47	12	15	21
Run – Off - Road		191	30	56	23	26	34
2-2 UP GRADED EXTENDED GUARDRIL	152						
All Accidents		3257	15	9	13	13	16
Run – Off –Road		1600	26	10	27	25	26
2-3 DRAINAGE STRUCTURE EXTENDED DUARDRAIL	26						
All Accidents		1634	36	18	34	33	38
Run- Off – Road		1027	44	27	36	36	50
2-4 SLOPE FLATTENING	11						
All Accidents		647	(4)	30	(15)	(12)	2
Run – Off – Road		252	10	30	18	19	(2)
2-5 VEGETATION/ OBSTACLE REMOVAL	16						
All Accidents		92	61	0	59	58	64
Run- Off - Road		64	77	100	76	77	76
2-6 NEW/ UPGRADED MEDIAN BARRIER	2						
All Accidents		541	36	60	26	28	39
Run- Off – Road		116	35	50	11	13	46
SS/Op Head – on		1	0	0	0	0	0

NOTE: Underlined numbers represent statistically significant rate reductions. Numbers in parentheses represent rate increases

ACCIDENT RATE REDUCTION LEVELS WHICH MAY BE ATTAINABLE FROM VARIOUS SAFETY IMPROVEMENTS (ARIZONA DATA)

			% REDUCTION IN ACCIDENT RATES				
TYPE OF IMPROVEMENTS	**NO OF PROJECTS**	**NO OF BEFORE ACCT'S**	**ALL**	**FATAL**	**INJURY**	**FATAL & INJURY**	**PDO**
2-7 IMPACT ATTENUATORS	15						
All Accidents		61	41	(100)	55	50	36
Run- Off- Road		22	45	0	30	30	58
2-8 OBJECT MARKERS	368						
All Accident		416	16	41	17	19	14
Run- Off – Road		171	29	60	24	29	29
2-9 DELINEATION	106						
All Accidents		663	11	8	19	18	4
Run- Off – Road		133	34	14	43	40	24
Nighttime		112	25	14	41	38	10
SS/ Op Head-On		15	67	100	25	63	71
2-10 ANIMAL FENCING	16						
All Accidents		295	(12)	0	(17)	(15)	(9)
Animal		68	66	0	91	91	61
2-11 ANIMAL REFLECTORS	2						
All Accidents		61	10	0	6	6	11
Nighttime Animal		4	25	0	0	0	25
2-12 SNOW FENCING	1						
All Accidents		17	71	0	83	83	64
Snowy Pavement		12	58	0	67	67	56

NOTE: Underlined numbers represent statistically significant rate reductions. Numbers in parentheses represent rate increases

ACCIDENT RATE REDUCTION LEVELS WHICH MAY BE ATTAINABLE FROM VARIOUS SAFETY IMPROVEMENTS (ARIZONA DATA)

			% REDUCTION IN ACCIDENT RATES				
TYPE OF IMPROVEMENTS	**NO OF PROJECTS**	**NO OF BEFORE ACCT'S**	**ALL**	**FATAL**	**INJURY**	**FATAL & INJURY**	**PDO**
2-13 ROCKFALL CONTAINMENT	1						
All Accidents		7	14	0	0	0	25
Strike Rocks		1	100	0	0	0	100
2-14 ILLUMINATION	2						
All Accidents		154	19	0	8	8	23
Nighttime		50	30	100	35	42	23
3-INTERSECTIONS INTERCHANGES							
3-1 NEW SIGNAL	73						
All Accidents		1024	(17)	(14)	(20)	(20)	(15)
Angle		443	42	60	39	40	45
3-2 NEW SIGNAL GEOMETRIC REVAMP	23						
All Accidents		419	21	57	28	30	13
Angle		247	68	56	73	72	63
SS/Same		15	53	0	100	100	42
Pedestrian		6	33	100	0	33	0
3-3 REVAMPED SIGNAL	20						
All Accidents		645	9	0	3	3	13
Angle		210	32	100	37	37	27
Left- Turn		115	3	0	(44)	(44)	26
Pedestrian		7	57	0	50	50	100

NOTE: Underlined numbers represent statistically significant rate reductions. Numbers in parentheses represent rate increases

ACCIDENT RATE REDUCTION LEVELS WHICH MAY BE ATTAINABLE FROM VARIOUS SAFETY IMPROVEMENTS (ARIZONA DATA)

			% REDUCTION IN ACCIDENT RATES				
TYPE OF IMPROVEMENTS	**NO OF PROJECTS**	**NO OF BEFORE ACCT'S**	**ALL**	**FATAL**	**INJURY**	**FATAL & INJURY**	**PDO**
3-4 REVAMPED SIGNAL & GEMETRIC REVAMP	19						
All Accidents		841	40	50	33	34	43
Rear – End		338	48	100	45	45	50
Left- Turn		152	18	50	24	25	11
Angle		129	19	0	21	20	19
Improper Turn		83	80	0	83	83	79
SS/Same		50	48	0	17	17	52
Pedestrian		7	(14)	100	(60)	(33)	100
3-5 LEFT- TURN PHASING	13						
All Accidents		623	15	33	6	6	21
Left-turn		133	35	50	4	6	52
3-6 TURN LANES	24						
All Accidents		180	6	100	(1)	3	9
Rear-End		53	(8)	100	(40)	(31)	3
Angle		40	13	100	14	17	6
Left- Turn		33	24	100	33	38	12
SS/Same		17	59	0	75	75	54
Improper Turn		13	54	0	25	25	67
3-7 GEOMETRIC REVAMP	25						
All Accidents		75	43	0	71	71	20
Angle		23	17	0	58	58	(27)
Run- Off- Road		18	67	0	80	80	50
Rear- End		15	60	0	100	100	33
Improper Turn		12	100	0	100	100	100
Left – Turn		3	67	0	50	50	100
SS/Same		3	67	0	100	100	50

NOTE: Underlined numbers represent statistically significant rate reductions. Numbers in parentheses represent rate increases

ACCIDENT RATE REDUCTION LEVELS WHICH MAY BE ATTAINABLE FROM VARIOUS SAFETY IMPROVEMENTS (ARIZONA DATA)

			% REDUCTION IN ACCIDENT RATES				
TYPE OF IMPROVEMENTS	**NO OF PROJECTS**	**NO OF BEFORE ACCT'S**	**ALL**	**FATAL**	**INJURY**	**FATAL & INJURY**	**PDO**
3-8 ILLUMINATION	18						
All Accidents		143	(48)	0	(14)	(14)	(73)
Nighttime		45	18	0	29	29	8
3-9 SIGHT DISTANCE IMPROVEMENT	58						
All Accidents		586	7	0	6	5	8
Angle		165	21	75	3	7	31
Rear- End		145	10	0	17	17	4
Left- Turn		115	13	0	21	21	3
Improper Turn		54	30	0	30	30	29
					-		
3-10 CHANNELIZATION PAVEMENT MARKINGS	17						
All Accidents		127	0	100	(4)	(2)	1
Left- Turn		32	19	0	9	9	24
Angle		27	(33)	100	(50)	(36)	(31)
Improper Turn		12	17	0	60	60	(14)
Pedestrian		5	80	0	100	100	(100)
SS/Same		4	25	0	0	0	33
3-11 CHANNELIZATION SIGNING	15						
ALL Accidents		110	14	(100)	(2)	(7)	27
Left- Turn		22	36	(100)	36	27	45
Angle		14	14	0	(50)	(50)	63
SS/Same		6	67	0	100	100	33
Improper Turn		4	100	0	100	100	100

NOTE: Underlined numbers represent statistically significant rate reductions. Numbers in parentheses represent rate increases

ACCIDENT RATE REDUCTION LEVELS WHICH MAY BE ATTAINABLE FROM VARIOUS SAFETY IMPROVEMENTS (ARIZONA DATA)

			% REDUCTION IN ACCIDENT RATES				
TYPE OF IMPROVEMENTS	**NO OF PROJECTS**	**NO OF BEFORE ACCT'S**	**ALL**	**FATAL**	**INJURY**	**FATAL & INJURY**	**PDO**
3-12 CROSS ROAD/SIDE SIGNING	63						
All Accidents		82	33	100	56	59	15
Rear- End		26	27	0	38	38	(75)
Angle		21	29	100	25	50	20
Improper Turn		14	64	0	86	86	43
Left Turn		7	86	0	75	75	100
3-13 STOP SIGNS	40						
All Accidents		85	19	0	20	20	18
Angle		26	8	0	0	0	17
Rear- End		25	48	0	67	67	38
Left-Turn		18	22	0	14	14	27
3-14 YIELD SIGNS	6						
All Accidents		35	(37)	0	25	25	(89)
Angle		7	43	0	33	33	50
3-15 SIGNAL REMOVAL	2						
All Accidents		5	100	0	100	100	100
Rear-End		4	100	0	100	100	100
4 - TRAFFIC CONTROL DEVICES							
4-1 EDGELINE MARKING	4						
All Accidents		79	30	(100)	63	52	15
Run- Off – Road		37	30	0	60	56	10

NOTE: Underlined numbers represent statistically significant rate reductions. Numbers in parentheses represent rate increases

ACCIDENT RATE REDUCTION LEVELS WHICH MAY BE ATTAINABLE FROM VARIOUS SAFETY IMPROVEMENTS (ARIZONA DATA)

			% REDUCTION IN ACCIDENT RATES				
TYPE OF IMPROVEMENTS	**NO OF PROJECTS**	**NO OF BEFORE ACCT'S**	**ALL**	**FATAL**	**INJURY**	**FATAL & INJURY**	**PDO**
4-2 RAISED PAVEMENT MARKINGS	43						
All Accidents		4275	11	16	11	12	11
Nighttime		1309	16	35	10	12	18
Run-Off – Road		800	33	23	37	37	31
SS/Same		431	13	100	6	7	14
SS/Op&Head-on		41	12	40	(15)	(4)	38
4-3 RUMBLE STRIPS	5						
All Accidents		43	53	83	65	73	29
Run- Off – Road		28	54	75	56	60	38
SS/Op&Head –On		5	80	100	100	100	67
4-4 NEW CURVE SIGNING	188						
All Accidents		558	14	55	20	24	3
Run-Off - Road		328	17	57	24	27	1
SS/Op&Head- On		73	29	57	47	49	3
SS/Same		20	75	100	100	100	71
4 –5 UPGRADED CURVE SIGNING	138						
All Accidents		439	21	6	23	22	21
Run- Off – Road		286	21	0	25	23	18
SS/Op&Head- On		53	26	50	11	14	34
Rear- End		25	48	0	38	38	76
SS/Same		5	100	100	100	100	100
4 – 6 ICY PAVEMENT SIGNING	20						
All Accidents		247	(15)	67	(24)	(13)	(17)
Icy Pavement		76	(22)	100	(52)	(42)	(16)

NOTE: Underlined numbers represent statistically significant rate reductions. Numbers in parentheses represent rate increases

ACCIDENT RATE REDUCTION LEVELS WHICH MAY BE ATTAINABLE FROM VARIOUS SAFETY IMPROVEMENTS (ARIZONA DATA)

			% REDUCTION IN ACCIDENT RATES				
TYPE OF IMPROVEMENTS	**NO OF PROJECTS**	**NO OF BEFORE ACCT'S**	**ALL**	**FATAL**	**INJURY**	**FATAL & INJURY**	**PDO**
4 –7 SLIPPERY WHEN WET SIGNING	185						
All Accidents		1819	7	(81)	10	6	8
Wet Pavement		323	31	0	29	28	33
4-8 NARROW BRIDGE SIGNING	9						
All Accidents		15	47	0	86	86	13
Run-Off – Road		6	50	0	100	100	0
SS/Opp. & Head – On		5	20	0	100	100	(33)
4 – 9 WATCH FOR ROCKS SIGNING	32						
All Accidents		342	13	0	13	12	14
Strike Rocks		33	64	0	88	88	56
4 –10 ANIIMAL WARNING SIGNING	195						
All Accidents		2039	10	(15)	8	6	13
Strike Animals		400	18	83	2	12	19
4 –11 INTERSTATE SIGNING	20						
All Accidents		3961	7	8	10	10	25
5 - PEDESTRIANS							
-							
5– 1 SIDWALKS	4						
All Accidents		128	(15)	100	(70)	(58)	7
Hit Pedestrian		9	89	100	88	89	0

NOTE: Underlined numbers represent statistically significant rate reductions. Numbers in parentheses represent rate increases

ACCIDENT RATE REDUCTION LEVELS WHICH MAY BE ATTAINABLE FROM VARIOUS SAFETY IMPROVEMENTS (ARIZONA DATA)

			% REDUCTION IN ACCIDENT RATES				
TYPE OF IMPROVEMENTS	**NO OF PROJECTS**	**NO OF BEFORE ACCT'S**	**ALL**	**FATAL**	**INJURY**	**FATAL & INJURY**	**PDO**
5– 2 PEDESTRIAN OVERPASS	6						
All Accidents		15	(33)	0	0	0	(62)
Hit Pedestrian		3	67	0	50	67	0
5 – 3 PEDESTRIAN SIGNING	96						
All Accidents		1870	4	4	8	8	1
Hit Pedestrian		66	15	22	17	17	(33)
6- STRUCTURES							
6-1 BRIDGE	23						
WIDENING		76	36	50	38	38	32
All Accidents		54	44	50	27	29	62
Run – Off – Road		7	57	0	100	100	0
SS/Same							
6 –2 BRIDGE	17						
REPLACEMENT		52	62	100	36	40	70
All Accidents		23	52	100	0	17	65
Run- Off – Road		6	100	0	100	100	100
Rear – End		1	100	0	0	0	100
SS/Op&Head-On		1	100	0	100	100	0
SS/Same							
6 – 3 NEW BRIDGE	13						
All Accidents		27	11	0	38	36	(15)
Wet Pavement		4	50	0	50	50	50

NOTE: Underlined numbers represent statistically significant rate reductions. Numbers in parentheses represent rate increases

ACCIDENT RATE REDUCTION LEVELS WHICH MAY BE ATTAINABLE FROM VARIOUS SAFETY IMPROVEMENTS (ARIZONA DATA)

			% REDUCTION IN ACCIDENT RATES				
TYPE OF IMPROVEMENTS	**NO OF PROJECTS**	**NO OF BEFORE ACCT'S**	**ALL**	**FATAL**	**INJURY**	**FATAL & INJURY**	**PDO**
6 –4 BRIDGE BARRIER UPGRADE	45						
All Accidents		51	25	(100)	50	41	14
Run- Off - Road		33	42	0	46	46	40
7 – RAILROAD – HIGHWAY CROSSINGS							
7 –1 NEW FLASHING LIGHTS	3						
All Accidents		7	43	0	0	0	60
Hit Train		0	0	0	0	0	0
7 – 2 UPGRADED FLASHING LIGHTS	7						
All Accidents		28	43	0	29	29	57
Hit Train		8	38	0	0	0	60
7 – 3 NEW GATES TO REPLACE X-BUCKS	105						
All Accidents		107	59	90	73	76	44
Hit Train		48	96	100	95	96	95
7 –4 NEW GATES TO SUPPLEMENT FLASHING LIGHTS	22						
All Accidents		34	62	100	71	73	53
Hit Train		10	80	100	100	100	60

NOTE: Underlined numbers represent statistically significant rate reductions. Numbers in parentheses represent rate increases

ACCIDENT RATE REDUCTION LEVELS WHICH MAY BE ATTAINABLE FROM VARIOUS SAFETY IMPROVEMENTS (ARIZONA DATA)

			% REDUCTION IN ACCIDENT RATES				
TYPE OF IMPROVEMENTS	**NO OF PROJECTS**	**NO OF BEFORE ACCT'S**	**ALL**	**FATAL**	**INJURY**	**FATAL & INJURY**	**PDO**
7 –5 SURFACE IMPROVEMENT	16						
All Accidents		29	7	(100)	0	(22)	20
Hit Train		5	20	(100)	50	(50)	67
Run- Off –Road		8	25	0	33	33	20
7 –6 SIGNING	13						
All Accidents		4	100	0	100	100	100
Hit Train		2	100	0	100	100	0
Run- Off- Road		2	100	0	100	100	100
7 – 7 PAVEMENT MARKINGS	141						
All Accidents		169	48	(100)	43	42	51
Hit Train		43	56	(100)	50	43	62
Rear- End		71	58	0	52	52	62
Run- Off - Road		32	22	0	8	8	30

NOTE: Underlined numbers represent statistically significant rate reductions. Numbers in parentheses represent rate increases